Claims

1. Method for the production of reinforced tube-shaped structures (1) from rubber layers and reinforcement layers (2, 3) with the steps of:

a) applying a first rubber layer (2a) with a first extrusion unit (4a) to a series of sequential rigid cylindrical mandrels (5) which are coupled to each other and which are driven at an advancement speed (v) in the direction of an advancement axis (X);

b) applying a first filament layer at defined desired filament angles (α_1) referred to the advancement axis (X) with a bobbin creel unit (10a) having means which rotate about the advancing mandrels (5);

c) applying at least one further rubber layer (2b) to the first filament layer utilizing at least one additional extrusion unit (4b);

characterized by:

d) continuously measuring the advancement speed (v) of the mandrels (5);

e) controlling the rubber quantity, which is applied via the first extrusion unit (4a), in dependence upon the measured advancement speed (v) in order to obtain a defined desired thickness of the first rubber layer (2a);

f) controlling the rotational speed of the first bobbin creel unit (10a) during the rotation about the mandrels (5) in dependence upon the advancement speed (v) in order to obtain a filament layer having the defined desired filament angles (α_1).

2. Method of claim 1, characterized by continuously measuring

the thickness (d_a) of the first rubber layer (2a) and controlling the rubber quantity, which is applied via the first extrusion unit (4a), in dependence upon the measured thickness (d_a).

3. Method of claim 1 or 2, characterized by controlling the rotational speed of the bobbin creel unit (10a) in step (f) in dependence upon the measured thickness (d_a) of the first rubber layer (2a).

4. Method of one of the claims 1 to 3, characterized by controlling the rubber quantities, which are applied via the further extrusion unit (4) in dependence upon the advancement speed (v) in order to obtain a defined desired thickness of the additional rubber layers (2).

5. Method of one of the above claims, characterized by controlling the mandrel advancement speed in accordance with the measured advancement speed (v).

6. Method of one of the above claims with the further steps:

applying at least one further filament layer to each rubber layer (2) at defined desired filament angles (α_2) referred to the advancement axis (X) in each case with a further bobbin creel unit (10b) which rotates about the forwardly driven mandrels (5);

applying at least one additional rubber layer (2c) to each filament layer utilizing a corresponding extrusion unit (4c);

characterized by:

controlling the rotational speeds of the additional bobbin creel units (10) during the rotation about the mandrels (5) in dependence upon the advancement speed (v) and/or in dependence

upon the rotational speed of the first bobbin creel unit (10a); and,

controlling the rotational speeds of the additional bobbin creel units (10) in dependence upon a desired thickness of the additional rubber layer (2) and the desired filament angles (α_2) with the bobbin creel units being coupled to each other via a dead time and coupling factors.

7. Method of one of the above claims, characterized by variably adjusting the filament angles (d) by controlling the rotational speeds of the bobbin creel units (10) with the bobbin creel units (10) being coupled to each other over a dead time and coupling factors so that a change of the filament angle of a filament layer is coupled by a bobbin creel unit to a position of the reinforced tube-shaped structure to a corresponding change of the filament angle of additional filament layers at the same position via additional bobbin creel units.

8. Method of one of the above claims, characterized by controlling the rubber quantities, which are applied via the extrusion units (4), in dependence upon the measured mean wall thickness.

9. Method of one of the above claims, characterized by controlling the rubber quantity, which is applied by an extrusion unit (4), in dependence upon the particular pressure in the injection head of the corresponding extrusion unit (4).

10. Method of one of the above claims, characterized by controlling the thicknesses (d) of the applied rubber

layers (2a, 2b, 2c) via rotational speed control of a gear pump (11), which is mounted, in each case, between the extruder and the extrusion head of an extrusion unit (4).

11. Method of one of the above claims, characterized by measuring the thickness (d) of the applied layers at several positions on the periphery of the reinforced tube-shaped structure (1) for control, fault detection and/or fault characterization when there is a deviation from a desired value with the deviation going beyond a defined tolerance limit.

12. Method of claim 11, characterized by determining the layer thickness from the mean value of the thicknesses (d) of the applied layers with the thicknesses (d) being measured at the periphery.

13. Method of one of the claims 11 or 12, characterized by rotating a unit to measure the thicknesses (d) of the applied layers over the time about the periphery of the reinforced tube-shaped structure (1) and recording the thickness (d) at several peripheral positions.

14. Method of one of the claims 11 to 13, characterized by contactlessly measuring the outer edges of the reinforced tube-shaped structure (1) and the outer edges of the mandrel (5) and determining the thickness of the reinforced tube-shaped structure (1) from the positions of the outer edges.

15. Method of one of the above claims, characterized by optically measuring the outer edges of the reinforced tube-shaped

structure (1) and inductively measuring the outer edges of the mandrel.

16. Method of one of the above claims, characterized by applying a separating agent to the mandrels (5) with a separating agent application unit (7) in advance of applying the first rubber layer (2a) and controlling the applied separating agent quantity in dependence upon the advancement speed (v) of the mandrels (5).

17. Method of claim 16, characterized by applying separating agents to the outermost rubber layer (2) and controlling the applied quantity of separating agent in dependence upon the advancement speed (v) of the mandrels (5).

18. Method of one of the above claims, characterized by measuring process variables during the application of the rubber layers and the reinforcement layers (2, 3); marking defective regions of the reinforced tube-shaped structure (1) when the process variables exceed or drop below a corresponding fault tolerance amount; optically detecting the marked defective regions; and, separating out the sections of the reinforced tube-shaped structure (1) which are recognized as defective.

19. Method of one of the above claims, characterized by marking sections of the reinforced tube-shaped structure (1) after the application of the topmost rubber layer (2c) with a product marking, especially with the production time and/or a charge number wherein the marking identifies a separation location and the assembly facility and direction of assembly of the structure (1).

20. Arrangement for making reinforced tube-shaped structures comprising:

a) a first extrusion unit (4a) for applying a first rubber layer (2a) to a series of sequential rigid cylinder-shaped mandrels (5), which are coupled to each other, the mandrels being driven at an advancement speed (v) in a direction of an advancement axis (X);

b) a first bobbin creel unit (10a), which rotates about the advancing mandrels (5), for applying a first filament layer at defined desired filament angles (α_1) referred to the advancement axis (X);

c) at least one additional extrusion unit (4b) for applying at least one additional rubber layer (2b) to the first filament layer;

characterized by:

d) advancement speed measuring means (14a, 14b) for continuously measuring the advancing speed (v) of the mandrels (5);

e) at least one control unit (15, 16) for driving the extrusion units (4) and the bobbin creel units (10) with the control unit (15, 16) being configured for:

controlling the rotational speed of the first bobbin creel unit (10a) during the rotation about the mandrels (5) in dependence upon the advancement speed (v) in order to obtain a filament layer having defined desired filament angles (α_1);

controlling the rubber quantity, which is applied by the first extrusion unit (4a), in dependence upon the measured advancement speed (v) in order to obtain a defined desired thickness of the first rubber layer (2a).

21. Arrangement of claim 20, characterized by layer thickness measuring means (9a) for continuously measuring the thickness (d_a) of the first rubber layer (2a) and controlling the rubber quantity, which is applied by the first extrusion unit (4a), in dependence upon the measured mean thickness (d_a).

22. Arrangement of claim 20 or 21, characterized by additional layer thickness measuring means (9b, 9c) behind the additional extrusion units (4b, 4c) to continuously measure the thickness (d) of the particular rubber layer (2) and controlling the rubber quantity in dependence upon the correspondingly measured mean thickness (d), the rubber quantity being applied via the corresponding extrusion unit (4b, 4c).

23. Arrangement of one of the claims 20 to 22, characterized in that the control unit (15, 16) is also configured for controlling the rubber quantities in dependence upon the advancement speed (v) in order to obtain a defined desired thickness of the additional rubber layers (2b) with the rubber quantities being applied via the additional extrusion units (4).

24. Arrangement of one of the claims 20 to 23, characterized in that the control unit (15, 16) is configured for controlling the mandrel advancement speed in accordance with the measured advancement speed (v).

25. Arrangement of one of the claims 20 to 24, characterized by:

at least one additional bobbin creel unit (10) for applying an additional filament layer to the particular rubber layer (2b) at a defined desired filament angle (α_2) referred to the

advancement axis (X); and,

at least one additional extrusion unit (4) for applying additional rubber layers (2) to respective filament layers.

26. Arrangement of the one of the claims 20 to 25, characterized by at least one additional control unit (15, 16) which is configured to:

control the rotational speed of the additional bobbin creel units (10) in dependence upon a desired thickness of the respective rubber layers (2) and the respective desired filament angles (α_2);

control the additional bobbin creel units (10) during rotation about the mandrels (5) in dependence upon the advancement speed (v); and,

control the additional rubber quantity, which is applied by the additional extrusion units (4), in dependence upon the measured advancement speed (v) of the mandrels (5).

27. Arrangement of one of the claims 20 to 26, characterized by respective gear pumps (11) between an extruder and an extrusion head of an extrusion unit (4) for controlling the thickness of the applied rubber layers (2) with the control taking place via a rotation speed change of the gear pumps (11).

28. Arrangement of one of the claims 20 to 27, characterized in that the layer thickness measuring means (9) has measuring units for measuring the outer edges of the reinforced tube-shaped structure (1) at several positions on the periphery of the tube-shaped structure (1) and at least one contactless measuring sensor for detecting the outer edges of the mandrel (5).

29. Arrangement of claim 28, characterized in that the layer thickness measuring means (9) for recording the outer edges at several positions on the periphery of the reinforced tube-shaped structure (1) are rotatable about the reinforced tube-shaped structure (1).

30. Arrangement of claim 28 or 29, characterized by computing means, which are connected to the layer thickness measuring means (9) and are configured for determining the thickness of the reinforced tube-shaped structure (1) from the mean value of the specific thicknesses at several peripheral positions of the reinforced tube-shaped structure (1).

31. Arrangement of one of the claims 28 to 30, characterized in that at least one measuring sensor for the outer edges of the mandrel is an inductive sensor.

Summary

A method for the production of reinforced tube-shaped structures (1) of rubber layers and reinforcement layers (2, 3) has the steps of:

a) applying a first rubber layer (2a) with a first extrusion unit (4a) onto a series of sequential rigid cylindrical mandrels (5) which are coupled to each other and which are driven at an advancement speed (v) in the direction of an advancement axis (X);

b) applying a first filament layer at defined desired filament angles (α_1) referred to the advancement axis (X) with a bobbin creel unit (10a) having means which rotate about the advancing mandrels (5);

c) applying at least one further rubber layer (2b) to the first filament layer utilizing at least one additional extrusion unit (4b);

d) continuously measuring the advancement speed (v) of the mandrels (5);

e) controlling the rubber quantity, which is applied via the first extrusion unit (4a), in dependence upon the measured advancement speed (v) in order to obtain a defined desired thickness of the first rubber layer (2a);

f) controlling the rotational speed of the first bobbin creel unit (10a) during the rotation about the mandrels (5) in dependence upon the advancement speed (v) in order to obtain a filament layer having a defined desired filament angle (α_1).

Reference to FIG. 1